Returning to Figure 1, the system of the invention further includes a stabilizer 70 for stabilizing the surface of the heart or other organ during a surgical procedure. Stabilizer 70 may be mounted either to rails 28, 29 or to crossbeam 22 by means of a mounting base 72. As shown more clearly in Figures 5-8, stabilizer 70 includes a shaft 74 having a distal end 76 and a proximal end 78. A foot 80 is pivotably mounted to distal end 76 by means of a ball joint 82. Foot 80 is configured to engage the surface of the heart on opposing sides of an anastomosis site, preferably having a pair of arms 84 generally parallel to each other and spaced apart by a distance in the range of about 1-5 cm. Arms 84 have a generally flat portion 86 for engaging the heart, an angled portion 88 sloping upwardly from flat portion 86, and a proximal portion 90 which connects arms 84 and may have a curved, angled, or other suitable shape for attachment to a stem 92 coupled to ball joint 82. The bottom surfaces of arms 84 are adapted for atraumatic engagement with the epicardium, usually being smooth and flat. In a preferred embodiment, a friction-enhancing element is disposed on the bottom surfaces of flat portions 86. For example, the bottom surfaces may be textured with grooves, ribs, knurling, projections or other features, or they may be coated or covered with a friction-enhancing material such as foam, Dacron gauze, no-slip material, or a roughened or textured metal or plastic plate. Such material will enhance friction with the epicardium sufficiently to prevent slippage and migration of the foot, but not to such an extent as to injure the epicardial tissue.

For purposes of locking foot 80 in a selected position relative to shaft 74, a rod 89 is slidably disposed within a channel 93 in shaft 74, as shown in Fig. 7. Rod 89 has a distal end 95 which engages ball 97 of ball joint 82. An actuator on the proximal end of shaft 74 has a rotatable knob 99 having a threaded body 101 which is received in a threaded socket 103 attached to shaft 74. A distal end of threaded body 101 is attached to proximal end 105 of rod 89. In this way, rotation of knob 99 drives rod 89 distally into tight, locking engagement with ball 97, thus locking foot 80 in position.

It should be understood that stabilizer 70 and foot 80 may have various other configurations and features. For example, foot 80 may have an annular ring shape or angular polygonal shape, or have simply a single heart-engaging arm. Stabilizer 70 may further have a suction lumen and suction holes or cups on the bottom surface of foot 80 in order to apply suction to the epicardium for enhanced stability and

immobility. Other features and configurations may also be provided, such as those described in US Patent No. 5,807,243, assigned to the assignee of the present application and hereby incorporated herein by reference.

Mounting base 72 includes a carriage 90 adapted for slidable engagement with rails 28, 29, a turret 92 rotatably mounted to carriage 90, and a clamp 94 rotatably mounted to turret 92. Carriage 90 has a channel 96, as shown in Figure 7, configured to slide onto rails 28, 29 or crossbeam 22. Channel 96 has a pair of inwardly projecting lips 98 configured to be positioned within side channels 30 in arms 24, 26 or side channels 42 in crossbeam 22. For the purpose of clamping carriage 90 in a selected position along rails 28, 29 or crossbeam 22, carriage 90 has a living hinge 100 which allows an outer portion 102 of carriage 90 to rotate toward and away from an inner portion 104. A lever 106 is rotatably mounted to carriage 90 and has a sloped cam 108 which engages a camming surface 109 on outer portion 102 so as to urge it toward inner portion 104 as lever 106 is actuated in the clockwise direction (see Figure 8). This locks carriage 90 in place along rails 28, 29 or crossbeam 22. Rotating lever 104 in the opposite direction allows outer portion 102 to rotate away from inner portion 104, thus allowing carriage 90 to be slid along or removed from rails 28, 29 or crossbeam 22. A stationary finger grip 110 is mounted to outer portion 102 of carriage 90 to enhance leverage during actuation of lever 104.

Referring to Figure 9, turret 92 preferably provides rotation about at least two axes. In an exemplary embodiment, turret 92 comprises a spherical joint 112 having a base 114 attached to carriage 90 with a hemispherical top surface116, and a socket 118 having a cavity 120, whereby socket 118 is rotatable about multiple axes relative to base 114. In order to secure socket 118 in a given position relative to base 114, a threaded post 122 is secured to base 114, extends upwardly through socket 118 and is coupled to a threaded cap 124 having a lower end in engagement with socket 118. In this way, socket 118 may be locked in a selected position by tightening cap 124 on post 122, thus pressing socket 118 into engagement with base 114.

Referring to Figure 10, clamp 94 is configured to hold shaft 74 of stabilizer 70, or any of various other surgical instruments and devices utilized with the invention. Like turret 92, clamp 94 preferably provides rotation about at least two axes. In an exemplary embodiment, clamp 94 has an inner member 130 and an outer member 132. Outer member 132 has a bore 134 in which shaft 74 is slidably positioned. A

cylindrical extension 136 on outer member 132 is slidably received within a cavity 138 in inner member 130. Cylindrical extension 136 has a tapered inner end 140 which engages a tapered surface 142 in cavity 138. Tapered inner end 140 has an opening 144 and inner member 130 has an opening 146 through which a rod 148 extends. Rod 148 has a ball 150 on its outer end which resides within cylindrical extension 136 and is retained therein by tapered inner end 140, opening 144 being smaller than ball 150. Rod 148 extends through socket 118 of turret 92 and has a threaded end 151 opposite ball 150. A threaded knob 152 engages threaded end 151, allowing outer member 132 to be drawn toward inner member 130 by rotating knob 152, thus clamping shaft 74 in bore 134. A spring 154 is disposed around threaded end 151 and engages knob 152 urging it outwardly. This provides a small amount of clamping force on shaft 74 even when knob 151 is loosened, preventing the inadvertant slippage of stabilizer 70 into the surgical site.

Clamp 94 preferably also includes a spherical joint 156 to provide additional degrees of freedom for positioning stabilizer 70. Inner member 130 has a hemispherical outer end 158 which is received in a clamp socket 160 attached to socket 118 of turret 92. Clamp socket 160 may be a conical, spherical, or otherwise tapered concavity allowing rotation of inner and outer members 130, 132 about multiple axes relative to turret 92. Opening 146 in inner member 130 has tapered edges and is sufficiently large to allow a wide range of rotational movement of inner member 130 about rod 148. Spherical joint 156 is locked in a selected position in the same way as clamp 94, by tightening knob 152, which pulls on rod 148 thus urging inner member 130 into tight engagement with clamp socket 160.

In use, retractor 20 of the invention is placed in sternotomy incision as shown in Figure 11. First and second blades 52, 54 of appropriate size and shape are attached to stationary arm 24 and movable arm 26. Movable arm 26 is positioned close to stationary arm 24 so that blades 52, 54 can be inserted into the incision. Key 40 is then turned to move movable arm 26 away from stationary arm 24, whereby by first and second blades 52, 54 retract the opposing tissue edges and widen the incision to expose the chest cavity. An incision is made in the pericardium (not shown in Fig. 11) and sutures are placed in the pericardial flaps. The sutures are drawn out of the chest and placed through channels 37 into slots 66 in suture stays 62, and tensioned